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WILLIAM CHAUVENET[1]

It is eminently fitting that the prize for mathematical exposition recently established by the Mathematical Association of America at the suggestion of its president, Dr. J. L. Coolidge, should bear the name of Chauvenet.[2] For Professor William Chauvenet, in whose honor this prize was named, had a real genius for exposition and lucid presentation, combined with a power of expression and purity of language unexcelled in American scientific literature. Although Professor Chauvenet's name has lived and will continue to live for many reasons, this new honor to his memory naturally revives an interest in his life and work.

It is therefore very appropriate that a biographical sketch of Professor Chauvenet should be read at this time before a combined meeting of mathematicians, astronomers and members of the History of Science Section of the American Association for the Advancement of Science, not only because of the historic value of his work but also because he was one of the first members of this association as well as one of its first presidents.

Professor Chauvenet's father, William Marc Chauvenet, the youngest of ten children, was born in Narbonne, France, in 1790, and, on account of the early death of his parents, was educated by two older brothers who lived in Italy. As secretary to one of these, who at that time was a chief commissary in Napoleon's army in Italy, he spent the early part of his life in that country. While there he had the time and means to cultivate a natural taste for music and literature. However, at the downfall of Napoleon he was forced to look elsewhere for means of support. He then came to Boston, and later to New York, as a partner in a silk importing company. This enterprise failing, he gave up business and bought a farm near Milford, Pike County, Pennsylvania. In the

[1] An address (here somewhat abridged) delivered at a joint session of Sections A, D and L of the American Association for the Advancement of Science, Kansas City, December 30, 1925. See Science, Vol. LXIII, No. 1622 (Jan. 29, 1926), pp. 123, 126, 138.

[2] See, *The American Mathematical Monthly*, Volume XXXII, No. 8, p. 439.

meantime he had married Miss Mary B. Kerr, of Boston. After a brief trial on the farm he removed to Philadelphia in 1821, where he again engaged in business.[3]

It was during the brief residence of his parents on the farm near Milford, Pennsylvania, that William Chauvenet entered Yale at the age of sixteen years. child he was carefully brought up, and the best schools were selected for his instruction. He lived in Philadelphia until he had attained the age of manhood. Early in life he manifested decided mathematical and musical abilities, as well as a mechanical proficiency. To his father he owed his love for music and literature, and from his mother he appears to have inherited his logical exactness and methodical reasoning power. He had a remarkable teacher in Dr. Samuel Jones, who at that time was head master of a boys' school in Philadelphia. It was due to the influence of Dr. Jones that Mr. Chauvenet consented to send his son William to Yale College. William Chauvenet entered Yale at the age of sixteen years. He graduated in 1840 with high honors, due as much to his classical as to his mathematical attainments.

When confronted with the choice of a career, it was a question with him whether it should be music or mathematics. However, the direction of his activities was to a large extent determined by his association with two eminent men. One of these was Professor Alexander Dallas Bache, head of Girard College in Philadelphia and later first president of the National Academy of Sciences. The other was Mr. Sears C. Walker, who established and directed the Astronomical Observatory at the Philadelphia High School. To the latter, Professor Chauvenet, in common with others, attributed the direction of his studies in astronomy.

Soon after leaving college, William Chauvenet was selected by Professor Bache to assist in a series of observations on terrestrial magnetism, which were undertaken at Girard College. An enduring friendship resulted from the association thus afforded these two men, and in later years Professor Bache's counsels were often sought by Professor Chauvenet.

In 1841 William Chauvenet was appointed professor of mathematics in the navy. According to the custom at that time, he was assigned to duty on shipboard to instruct midshipmen. However, after a few months of such service on the U. S. steamer *Mississippi,* he was so thoroughly convinced of the uselessness of the plan of teaching on shipboard, subject to the many inconveniences and interruptions of alternate life at sea and in port, that he resigned his appointment. The inadequacy of such instruction had already been so generally recognized in the navy that in 1839 the secretary of the navy established a school of preparation at the Naval Asylum in Philadelphia (originally intended and later used for veteran seamen). At this school midshipmen were permitted, but not required, to pass an academic year of eight months in the study of mathematics, necessary for promotion.

Professor David McClure was appointed to take charge of the class in mathematics and navigation. His death occurring early in 1842, Professor Chauvenet was appointed his successor. Professor Chauvenet showed so much ability and met with such marked success that it was decided to close all other schools gradually and discontinue all shore instruction elsewhere.[4]

Upon taking charge of the school, Professor Chauvenet immediately began the work of reform as far as was possible within the limits of the system then existing.[5] He arranged a more severe course of mathematical study than had before been prescribed and obtained for it the formal sanction of the secretary of the navy. He also introduced regular recitations and a system of marks for daily recitations. From the governor of the Naval Asylum he obtained a well-lighted classroom, blackboards, chronometers, sextants, etc. Not stopping there, he drew up a plan for the expansion of the institution into a regularly organized school in which all the subjects conceived to be indispensable to the naval officer were to be taught under competent instructors. In addition to this he pointed out the way which, at that time, made possible the establishment of the United States Naval Academy.

Seeing that attempts to get bills through Congress had failed and in all probability would fail again, it seemed to him that the only practical method was first to expand the course at the Naval Asylum. Then in frequent interviews with the secretary of the navy, Professor Chauvenet represented to him that the same power exercised by the secretary in sending the midshipmen to the Naval Asylum for one year and in sending one professor there to teach them might be exercised in retaining them there two years and in sending not only more naval professors, but also other officers of the service.

[3] Memoir of William Chauvenet, by J. H. C. Coffin, *National Academy of Sciences, Biographical Memoirs,* Vol. I. Washington, 1877, pp. 227–244.

[4] "History of the U. S. Naval Academy," J. R. Soley, Washington: Government Printing Office, 1876 (p. 38).

[5] See: A letter from Professor Chauvenet to Mr. T. G. Ford in an article (with a portrait) on William Chauvenet by Wm. H. Roever, "Washington University Studies," Vol. XII, Scientific Series, No. 2, pp. 97–117, 1925. See also: "The Teaching and History of Mathematics in the United States," Florian Cajori, Washington: Government Printing Office, 1890 (pp. 239–244).

Mr. George Bancroft, who was appointed secretary of the navy on March 4, 1845, at once appreciated the importance of a reform in naval instruction and resolved to avail himself of the power in his hands to effect it. He called upon the Board of Examination, which met at the Naval Asylum in June, 1845, for a detailed plan of a school, and especially consulted them upon the propriety of adopting Fort Severn at Annapolis as the site for such a school. He had fully adopted the idea of expanding the course of instruction without consulting Congress, but foresaw that as a regularly organized institution might thus gradually be brought into existence, room for expansion would be needed which could not be afforded by the Naval Asylum. Secretary Bancroft's next step was to refer the report of the board and all other documents relating to the subject in the possession of the department, to Commander F. Buchanan, with instructions to prepare, with such assistance as he might require, a plan for the organization of the Naval School at Fort Severn. At the same time he appointed Commander Buchanan superintendent of the school. This plan of organization, after some revision, was published in August, 1846, but carried into effect in October, 1845. Thus the United States Naval Academy was founded by Secretary of the Navy George Bancroft. But Professor Chauvenet did much to direct his attention to its necessity and feasibility and prepared the way for his success.

This was a great achievement, in view of the fact that numerous unsuccessful attempts had been made during the preceding thirty years to induce Congress to establish a school for the navy similar to that which it had established years before at West Point for the army.

Professor Chauvenet's efforts did not cease with the founding of the Academy at Annapolis. He was constantly urging farsighted plans for its further development, and during the next fourteen years his was the chief influence in its upbuilding.

From 1845 to 1850 there were only two classes, called the junior and senior classes, but even yet attendance was uncertain because of the fact that midshipmen were subject to call for sea service at any time. In 1850 a change was made which required of students a continuous attendance during two periods of two years each with an intermission between these of three years for sea service. Finally, a consecutive course of four years before sea service, with summer cruises, was adopted. The course was also improved as to the subjects taught, and the admission requirements were gradually raised.

Professor Chauvenet also advocated that graduates should be brought back, nominally as assistant instructors, in order to give them an opportunity for further study, and that the academy by its equipment for professional studies should offer inducements to this end. In his own department he made provision for such purpose by the erection of a small observatory which he equipped with an equatorial telescope and a meridian circle. This resulted in 1853 in the creation of a separate department of astronomy and navigation, with Professor Chauvenet at its head and director of the observatory.

The connection of Professor Chauvenet with the academy and its predecessor, the Naval Asylum, for a period of about eighteen years, in the various capacities of professor of mathematics and astronomy, member of the Academic Board and director of the observatory, is one of the most important facts in the early history of the academy. Various writers agree that he did more than any one else to establish the institution on a firm and scientific basis and that he raised the calling of the United States naval officer to a place of distinction.

In recognition of this service a memorial to Professor Chauvenet, in the form of a bronze tablet, has been placed in the library of the Naval Academy. The upper half is a bas-relief of the distinguished scientist and the lower half bears the following inscription:

1820 1870
William Chauvenet
Professor of Mathematics
United States Navy and
President of the Academic
Board from 1847 to 1850
Largely Through Whose
Efforts and Plan the Naval
Academy was Established
and Organized at Annapolis.

Professor Chauvenet's scientific writings, which will be discussed later, and his success as a teacher and administrator at Annapolis had attracted wide attention. It was therefore natural that his Alma Mater should wish to have him on the faculty. In 1855 he was asked to become professor of mathematics, but he was not ready then to give up his work at the Naval Academy. Again in 1859 he was sought as professor of astronomy and natural philosophy. At this time he was also offered the chair of mathematics and natural philosophy at Washington University, then recently established in St. Louis. Considering well the claims of these two institutions, one well established and of great reputation, the other just beginning life, but organized on plans which he approved, he decided in favor of Washington University, "where conscious usefulness would be his best reward."

Professor Chauvenet had a broad general culture and in addition to this he was already an outstanding

figure in the scientific world. Thus he brought to Washington University a symmetry of intellectual development which lent distinction to that new institution. It was not surprising, therefore, when his classmate of Yale, Joseph G. Hoyt, the first chancellor, died in 1862, that the directors of Washington University should select Professor Chauvenet as his successor.

He entered this new field of activity with the same energy and zeal which had characterized his work at the Naval Academy and he soon won the confidence and esteem of those with whom he was here associated. His inaugural address, delivered shortly after his appointment to the chancellorship, reveals his broad vision of the function of education.[6]

During Professor Chauvenet's connection with Washington University that institution prospered and became well known. The later years of his life were mainly occupied in building up this new institution much as the earlier ones had been in developing the Naval Academy. Thus, to use the words of his biographer, Professor J. H. C. Coffin, "In developing and giving character and reputation to two distinguished educational institutions, he had done a noble work."

Great as this work was, the contribution which Professor Chauvenet made to American science was of even more value, because it influenced and made possible the raising of the standard of instruction in many institutions, besides advancing this science. Of his masterful treatises on trigonometry, astronomy and geometry his biographer, Professor J. H. C. Coffin, says: "It is a marked evidence of the advancing progress of science among us that each of these works, published as a hazardous experiment and with the supposition that few copies only would be required, has met with an increasing demand from year to year." To obtain a notion of the scope and character of these works, one has only to read the reviews of them made shortly after they appeared. While these were made more than fifty years ago, it can still be said that no other trigonometry has yet appeared in America which is of the comprehensive character of Professor Chauvenet's. His work on astronomy is a classic and will long continue to be a valuable work of reference in all observatories. His geometry has been a model for many which have followed it.

The *Journal* of the Franklin Institute (Vol. XX, 3d series, p. 215) regards the work on trigonometry entitled, *"A Treatise on Plane and Spherical Trigonometry,"* published in 1850, as "an important addition to our mathematical literature, being the most complete treatise on trigonometry extant in the English language. While it contains everything useful to the mathematician and astronomer, the more elementary portions of the work are easily distinguished by the large type in which they are printed, and form of themselves a connected treatise, adapted to the wants of the young student." "Yet it pursued the subject," says Professor Coffin, "to its higher developments, supplying almost every want in astronomy and geodesy." "It introduced the American student to the methods of the German school, noted for the rigor and generalization and exhaustive character of its discussions, and to many topics wanting in all the textbooks in the highest colleges in this country and in England, and found by our mathematical students only in German, French or Latin. The Gaussian equations, the finite variations and differentials of trigonometric expressions, the solution of the general spherical triangle, the development of several functions into series of multiple angles, are instances most readily noted. What was found in many books was digested into a connected treatise, remarkable for its symmetry, its thorough exactness and the clearness, conciseness and purity of language of every expression. After the writings of Cagnoli, Gauss, Bessel and others, it was hardly to be expected that anything new could be developed. Yet there are not a few topics which are new, and others in which he improved the discussions of these great masters. At the time of its publication, trigonometry in many of our colleges was restricted to the simple cases of plane and spherical triangles, by trammeling geometric processes. Analytical trigonometry was but little known except to those engaged in astronomical or geodesic work. This book supplied a pressing need of the times, and, as a classic and complete work on the subject of which it treats, it will be long before it is superseded."

Of his "Manual of Spherical and Practical Astronomy," begun at Annapolis, but completed at St. Louis, his biographer says,

In Spherical Astronomy it embraces all the topics which come up in the work of an observatory, or in astronomical work on land or at sea, and each is treated with the exhaustive generality and mathematical rigor of the German school. The whole is wrought into a symmetrical treatise remarkable for its clearness and simplicity, which could only be the work of a master mind, fully conversant with the subjects which it discussed. As has been aptly said by one able to judge, "It represents astronomy in its most modern and perfected forms of research. Many of its investigations are either wholly or in part original, such, for example, as some of the formulae for latitude and eclipses, occultations of planets, improved method of lunar distances, etc." The second volume on Practical Astronomy evinces the same completeness and thoroughness of

[6] Inaugural Address of William Chauvenet, LL.D., as Chancellor of Washington University, June 17, 1863, St. Louis (George Knapp & Co.).

analysis. It discusses, in an elaborate and exhaustive manner, all the best instruments used for astronomical observatories, whether in the higher observatories, or in the more modest work in the field or at sea. An appropriate chapter on the method of least squares is added, in which the subject is treated with a perspicuity, and freedom from the mystery in which it has been shrouded, found nowhere else. Each chapter is a monograph by itself, but here treated in unison with the rest, and with a noted symmetry. The theory of each instrument is admirably discussed with all its needful appendages. It is not a minute description of a particular instrument, with its peculiar arrangements, but of its essential parts, while, as also in the first volume, there are many valuable suggestions and examples, illustrating what is needed and what is best in practice.

During the last winter of his life, Professor Chauvenet completed and published "A Treatise on Elementary Geometry," which was outstanding in many respects. Following the improved methods of the French school in presenting the elementary geometry of Euclid, he also added two appendices of great value. Of these the first contained numerous exercises with suggestions given less and less frequently as the work progressed. In this way "the discouraging difficulties which the young student commonly experiences in his first attempts at demonstrating new theorems, or solving new problems, are here obviated in a great degree." The second appendix was on the subject of modern geometry and although restricted to the properties of the straight line and circle, it served to give the student an introduction to this recently developed new geometry, which was but little known in America at that time.

In connection with the first appendix, and the work in general, Professor Coffin reminds us that next to those who are directly laboring to extend and advance science, they contribute to its progress who prepare fitting aids to the young beginner and remove the difficulties in his way.

In his early years in Philadelphia, Professor Chauvenet prepared a little book entitled "Binomial Theorem and Logarithms for the use of the Midshipmen at the Naval School, Philadelphia." (*Philadelphia,* 1843, pp. 92.) According to Professor Coffin it manifests the same thoroughness and exactness which are conspicuous in his later writings.

In addition to these books, Professor Chauvenet published a number of articles, a complete list of which is given in article of footnote 5. These were chiefly on trigonometrical and astronomical subjects. The most noted of these was on "A Method for Determining Lunar Distances." Concerning this method Professor Coffin says, "While equally rigorous with that of Bessel, it was adapted to the usual tables in the British and American Ephemerides, and so simply and admirably arranged that the non-mathematical navigator could use his method with almost as much facility as the imperfect processes usually employed."

It is evident that Professor Chauvenet had studied the great masters in the subjects which he treated and that he presented their conclusions and point of view, with his own original investigations, in his clear and forceful style, thus enriching and making accessible the literature in these subjects. That he had access to a well-selected library in his fields of work is shown by a glance at the catalogue of the library of the U. S. Naval Academy prepared by Professor J. H. C. Coffin in 1860. Professor Chauvenet was also responsible for the selection of much of this library, for, as Professor Coffin says in this catalogue, "the Academy is greatly indebted to Professor Chauvenet for his judicious selections, and his care of the Library for many years."

Another illustration of his ability, as well as of his versatility, is shown by some work which he did in connection with the design of the St. Louis (Eads) Bridge. Professor C. M. Woodward, who wrote a history of that bridge, says of Professor Chauvenet in an article entitled "Personal Recollections of Chancellor Chauvenet" and published in the Bulletin of the Washington University Association for 1905–1906, "If the reader would see a specimen of his work in Applied Mechanics, let him read the 'Theory of the Ribbed Arch' in my 'History of the St. Louis Bridge.' The analytical work is given almost exactly as it came from the hand of Professor Chauvenet." He also invented the apparatus for measuring with the greatest accuracy the elongation and compression of the specimens being tested by Colonel Henry Flad for modulus of elasticity and elastic limit in the preliminary work for the Eads Bridge. This apparatus is fully described in the history above referred to, and it contains the feature of a revolving mirror, which was Chancellor Chauvenet's personal invention.

Thus we have also an illustration of Professor Chauvenet's mechanical ability, which was already displayed in his youth. Another evidence of this, as well as of his thorough knowledge of stereographic projection, is shown by the invention of a device called the "great circle protractor" by which the navigator is enabled to lay down his course on a great circle of the globe with almost as much ease as on a rhumb line by a Mercator chart. Spherical triangles could readily be solved by this "protractor" to the nearest quarter of a degree. This invention was purchased by the U. S. Hydrographic Office not long after the close of the Civil War.

When one considers that all this work was done amidst his numerous duties of teaching and administration, it is not surprising to learn that on several occasions Professor Chauvenet was obliged to re-

linquish his duties on account of poor health. In the spring of 1864 his health gave way. Fortunately after a sojourn in Wisconsin and Minnesota it was so far restored that in the fall of 1865 he was again able to resume his duties at the university. But he devoted himself so assiduously to his duties that his health again failed and he was obliged in 1869 to give up his work. This time the effort to regain his health was in vain. He passed a summer in Colorado and Minnesota, the following winter in Philadelphia and the spring in South Carolina. Returning to St. Louis and then to Minnesota, "he finally closed a laborious, useful life at St. Paul, Minnesota, on December 13, 1870, in the 51st year of his age." He was buried in Bellefontaine Cemetery in St. Louis.

In his family the warmest traits of character were constantly exhibited. In 1842 soon after taking charge of the Naval School in Philadelphia, he married Miss Catherine Hemple of that city. Even in his most laborious days, he found time to join in the sports and amusements of his children and in later years to guide their reading and studies. He constantly manifested the religious faith which he professed, but he never obtruded the peculiarities of his faith on those who differed from him.

Professor Chauvenet was honored by being elected to the American Philosophical Society and to the American Academy of Arts and Sciences. In 1860 St. John's College, Annapolis, Maryland, conferred on him the degree LL.D. At the formation of the National Academy of Sciences he was one of the prominent members. He served on a number of its committees and was its vice president at the time of his death. As already stated, he was one of the first members of the American Association for the Advancement of Science. In 1859 he was elected general secretary and in 1869 at the Salem meeting he was elected president. At the next meeting in 1870, in the absence of Professor Chauvenet, who was too ill to attend, the vice president, Thomas Sterry Hunt, presided. At the following meeting, the president, Mr. Hunt, in announcing the death of Professor Chauvenet, said in part:

It was already feared at the time of his election to the presidency that failing health would prevent his presence in 1870, as was the case. He died at the age of fifty leaving behind him a record of which science and his country may be proud. During his connection of fourteen years with the Naval Academy he was the chief instrument in building up that institution, which he left in 1859 to go to St. Louis. It is not for me to pronounce a eulogy, to speak of his profound attainment in astronomy and mathematics or of his published works which have taken rank as classics in the literature of these sciences. Others more familiar with his field may in proper time and place attempt the task.

All who knew him can, however, join with me in testifying to his excellences as a man, instructor and friend. In his assiduous devotion to scientific studies he did not neglect the more elegant arts, but was a skillful musician and possessed of great general culture and refinement of taste. In his social and moral relations, he was marked by a rare elevation and purity of character, and has left to the world a standard of excellence in every relation of life which few can hope to attain.[7]

Wm. H. Roever

Washington University

THE TRANSMISSION OF HUMAN PROTOZOA[1]

Every class in the phylum Protozoa contains species that live in man, and some of these are of considerable importance in various parts of the world as disease-producing agents.

One of the most interesting phases in the life cycle of these parasitic Protozoa is that during which they are transmitted from one host to another, either directly or through an intermediate host. It is at this time that measures for prevention and control can most successfully be applied, measures which, from the standpoint of personal hygiene, protect the individual from infection, and, from the standpoint of public health, protect the general population, either rural or urban, from infection. The twenty-five species of human Protozoa that are usually recognized by protozoologists at the present time may be classified as follows with respect to their habitat within the body and the method by which they are transmitted.

I. *Intestinal Protozoa:*
- (1) Species transmitted by the contamination of food or drink by cysts.
  - (a) Intestinal Amœbae.
    - (1) *Endamœba histolytica,* the organism of amœbic dysentery and amœbic liver abscess.
    - (2) *Endamœba coli,* a harmless commensal living in the large intestine.
    - (3) *Endolimax nana,* similar to (2).
    - (4) *Iodamœba williamsi,* similar to (2).
    - (5) *Dientamœba fragilis,* similar to (2).
  - (b) Intestinal Flagellates.
    - (6) *Chilomastix mesnili,* a possible causative organism of flagellate diarrhea.
    - (7) *Embadomonas intestinalis,* probably a harmless commensal.

[7] Proceedings of the American Association for the Advancement of Science (1871) Vol. XX.

[1] From the Department of Medical Zoology, School of Hygiene and Public Health, the Johns Hopkins University and the London School of Hygiene and Tropical Medicine. This paper is an abstract of three lectures delivered at the London School of Hygiene and Tropical Medicine on April 18, 19 and 20, 1926.

(8) *Tricercomonas intestinalis*, also probably a harmless commensal.

(9) *Giardia lamblia*, accused of causing flagellate diarrhea.

(c) Coccidia.

(10) *Isospora hominis*, the agent of a type of diarrheic infection known as coccidiosis.

(d) Infusoria.

(11) *Balantidium coli*, the ciliate responsible for balantidial dysentery.

(2) Species transmitted by the contamination of food or drink by trophozoites.

(12) *Trichomonas hominis*, another flagellate accused of causing diarrhea.

(3) Species transmitted by contact in the trophozoite stage.

(13) *Endamœba gingivalis*, an amœba that lives in the mouth and that has been accused, probably unjustly, of causing pyorrhea.

(14) *Trichomonas buccalis*, apparently a harmless flagellate living in the mouth.

(15) *Trichomonas vaginalis*, a flagellate living in the vagina that may be pathogenic.

II. *Blood-inhabiting Protozoa:*

(1) Species transmitted by tsetse flies.

(16) *Trypanosoma gambiense*, the organism of Gambian sleeping sickness.

(17) *Trypanosoma rhodesiense*, the organism of Rhodesian sleeping sickness.

(2) Species transmitted by triatoma bugs.

(18) *Trypanosoma cruzi*, the organism of Chagas's disease or South American trypanosomiasis.

(3) Species transmitted (probably) by phlebotomus sand flies.

(19) *Leishmania donovani*, the agent of kala-azar.

(20) *Leishmania tropica*, the agent of oriental sore.

(21) *Leishmania americana*, the agent of espundia or South American leishmaniosis.

(4) Species transmitted by anopheline mosquitoes.

(22) *Plasmodium vivax*, of benign tertian malaria.

(23) *Plasmodium malariæ*, of quartan malaria.

(24) *Plasmodium falciparum*, of estivoautumnal or malignant tertian malaria.

III. *Tissue-inhabiting Protozoa:*

(25) *Sarcocystis* sp. (?), a parasite rarely reported in the muscle of man.

TISSUE-INHABITING PROTOZOA

For the sake of convenience the last-named parasite will be considered first. Protozoa of the genus *Sarcocystis* are frequent inhabitants of muscle in sheep, mice and many other lower animals in which they often produce diseased conditions that may prove fatal. Not more than ten authentic cases of sarcosporidiosis have been reported from man. The method of transmission in nature either to man or to the lower animals has never been determined. Laboratory experiments have demonstrated that mice become infected if fed on muscle from other mice containing spores (T. Smith, 1901),[2] that mice may likewise be infected if fed on diseased muscle from sheep (Erdmann, 1910),[3] that guinea pigs may be infected by feeding them on diseased muscle from mice (Negri, 1908;[4] Darling, 1910),[5] and that the infection may be transmitted if mice are fed the feces from diseased mice (Negri, 1910).[6] These results suggest that carnivorous and omnivorous animals may become parasitized either by eating diseased muscle or by ingesting food or drink contaminated by feces from diseased animals. Herbivorous animals, such as sheep and cattle, may be infected by the latter method but hardly by eating diseased tissue. The host-parasite specificity, that is, the rigidity with which one species of parasite is limited to one species of host, must be very weak in the case of *Sarcocystis*, since it can apparently live in several vertebrate hosts. This fact renders the "blind-alley theory" quite reasonable. This theory holds that the organisms found in man are really sarcosporida from lower animals that accidentally set up an infection in a human host from which they are unable to escape and hence have encountered a blind alley. *Sarcocystis* is not and probably never will be a successful human parasite, but its method of transmission remains one of the least known of any of the important protozoan parasites.

TRANSMISSION BY CONTACT

The two species of Protozoa that occur in the human mouth are apparently widespread, having been found practically wherever looked for. They likewise are known to be present in a large percentage of the general population. The amœba, *Endamœba gingivalis*, lives in the tartar of the teeth and in the materia alba around them. Probably at least one half of the general population is infected. It was once thought to be the causative agent of pyorrhea

[2] Smith, T., 1901, "The Production of Sarcosporidiosis in the Mouse by feeding Infected Muscular Tissue," *Jour. Exp. Med.*, 6: 1–21.

[3] Erdmann, R., 1910, "Beiträge zur Morphologie und Entwicklungsgeschichte des Hammelsarkosporids in der Mans." *Centrlb. Bact. Orig.*, 53: 510.

[4] Negri, A., 1908, "Beobachtungen über Sarkosporidien." *Centrlb. Bakt. Orig.*, 47: 56–61, 612–622.

[5] Darling, S. T., 1910, "Sarcosporidiosis in the opossum, etc.," *Bull. Path. Exot.*, 3: 513–517.

[6] Negri, A., 1910, "Beobachtungen über Sarkosporidien," *Centrlb. Bakt. Orig.*, 55: 373.

but is now considered harmless. *Trichomonas buccalis* the other mouth-inhabiting protozoon, is likewise widespread and occurs in perhaps a third or more of the general population. It lives in the mucus and tartar between the teeth and is probably harmless. Both of these species are no doubt transferred from one person to another by kissing.

The vaginal flagellate, *Trichomonas vaginalis,* lives in vaginal mucus, but has been reported also from the urine of men (Hegner and Taliaferro, 1924).[7] It apparently does not occur in young girls (Pronoschina, 1923)[8] but has been recorded in from ten to fifty per cent. of adult women (Brumpt, 1913;[9] Hegner, 1925).[10] Whether it is a pathogenic protozoon or not is still undecided. Transmission probably takes place during coitus.

TRANSMISSION OF TRICHOMONAS HOMINIS IN THE TROPHOZOITE STAGE BY THE CONTAMINATION OF FOOD OR DRINK

No cysts are known in the life history of this intestinal flagellate, hence it must be transmitted in the trophozoite stage. The only conceivable method of reaching the intestine appears to be by the fecal contamination of food or drink that is ingested by the host. The first question that arises is whether trophozoites are able to withstand the action of the digestive juices during their passage through the stomach and small intestines. It has been proved that *Trichomonas muris* is able to do so in the rat and there is every reason to believe that *Trichomonas hominis* can in man (Hegner, 1924).[11] The next problem is whether *Trichomonas* is able to live outside of the human body in fecal material long enough for food and drink to become contaminated. Experiments involving the cultivation of the flagellate in test tubes indicate that they are (Hegner and Becker, 1922).[12] An ovomucoid medium was used; a better solution has since been evolved known as the serum-saline-citrate medium. This consists of water 100 cc., NaCl 0.7 gms., Na Cit 1.0 gms. and Loeffler's dehydrated blood serum 0.5 gms. This mixture is placed in test tubes, about 10 cc. in each; then a sample of fecal material the size of a pea is obtained on the end of a toothpick and both toothpick and sample dropped into the tube; after cultivation for twenty-four hours at about 36° C. a drop from the top of the culture is placed on a slide and examined. Hegner and Becker found eight out of 110 persons positive by this method, whereas only two of these were discovered by direct fecal examination. The results of more recent work on a large scale are even more striking. They also found by making cultures at frequent intervals from a stool known to be infected that *Trichomonas hominis* remains alive at least seventy-nine hours in undiluted fecal material. That this species encounters considerable difficulty in reaching new hosts is indicated by the small percentage (about 3 per cent.) of persons infected. How food and drink become contaminated by these and other flagellates will be discussed later.

TRANSMISSION OF INTESTINAL PROTOZOA IN THE CYST STAGE BY THE CONTAMINATION OF FOOD OR DRINK

This is the most common method of transmission and is the way in which eleven of the fifteen human intestinal species succeed in invading new hosts. The percentages, in round numbers, of the general population that are estimated to be infected by these organisms, which give some idea of the effectiveness of this method of transmission, are as follows (the number of infections reported for those species for which percentages are not given is too small to furnish reliable figures):

	Per cent.		Per cent.
Endamœba histolytica	10	*Embadomonas intestinalis*	—
Endamœba coli	50	*Tricercomonas intestinalis*	—
Endolimax nana	25	*Giardia lamblia*	15
Iodamœba williamsi	10	*Isospora hominis*	—
Dientamœba fragilis	10	*Balantidium coli*	—
Chilomastix mesnili	10		

There is some evidence that racial differences exist with respect to susceptibility to infection with the various species listed; and there is no doubt that age has a distinct influence, since children are more often infected than adults. For example, about 40 per cent. of children have been found to be parasitized by *Giardia lamblia* and only about 15 per cent. of adults. Laboratory experiments likewise prove that the young of lower animals are more susceptible than adults of the same species.

The success of transmission depends to a considerable degree on the number of cysts discharged by the hosts and the ability of these cysts to live outside of the body until they are ingested by new hosts. The

[7] Hegner, R. W., and Taliaferro, W. H., 1924, "Human Protozoology." New York.

[8] Ponoschina, V. G., 1923, "On the Rôle of *Trichomonas vaginalis* in Human Pathology," *Russian Jour. Trop. Med.*, No. 1: 27–30.

[9] Brumpt, E., 1913, "Précis de Parasitologie." Paris.

[10] Hegner, R. W., 1925, "*Trichomonas vaginalis* Donné," *Amer. Jour. Hyg.*, 5: 302–308.

[11] Hegner, R. W., 1924, "Infection Experiments with *Trichomonas*," *Amer. Jour. Hyg.*, 4: 143–151.

[12] Hegner, R. W., and Becker, E. R., 1922, "The Diagnosis of Intestinal Flagellates by Culture Methods," *Jour. Parasit.*, 9: 15–23.

reproductive powers of parasites, including Protozoa, are enormous; for example, it has been estimated that a single person may pass several hundred million cysts of *Endamœba histolytica* in a single day. The viability of these cysts has been tested by the eosin method. One drop of one per cent. eosin solution is added to one drop of washed cysts; if the cysts take the stain, they are considered dead, if not, they are probably alive. It has been found that the cysts of *Endamœba histolytica* die within fifteen minutes if they are allowed to dry (Kuenen and Swellengrebel, 1913);[13] that they will live from sixteen days (Thomson and Thomson, 1916)[14] to one month (Wenyon and O'Connor, 1917)[15] in feces that are kept moist; that they will live for five months at room temperature if washed and kept in distilled water (Boeck, 1921);[16] that they will remain alive in the intestine of houseflies for about two days (Root, 1921);[17] and they will bring about infection in kittens after being stored at 2° C. for six days, but not after storage for two weeks (Sellards and Theiler, 1924).[18]

Our information regarding the cysts of other species is not so extensive, but we know that washed cysts of *Endamœba coli* will live for eight months; those of *Chilomastix mesnili* for six months; and those of *Giardia lamblia* for at least one month (Boeck, 1921);[17] and that the cysts of these species will remain alive within the intestines of flies for from sixteen to eighty hours (Root, 1921).[18] Furthermore, the thermal death point of these cysts has been found to range between 64° and 76° C., which is much above any temperature these organisms are subjected to in nature. Flies feed regularly on fecal material and the living cysts may pass through their digestive tract and be deposited on food or drink as early as seven minutes and probably up to three days after they are ingested.

[13] Kuenen, W. A., and Swellengrebel, N. H., 1913, "Die Entamöben des Menschen und ihre praktische Bedeutung," *Centrlb. Bakt. Orig.*, 71: 378–410.

[14] Thomson, J. G., and Thomson, D., 1916, "Some Observations on the Effect of Emetine Administration on the Free Vegetative Forms and Cysts of *Entamœba histolytica* and *Entamœba coli*," *Jour. Roy. Army Med. Corp.*, 26: 683–694.

[15] Wenyon, C. M., and O'Connor, F. W., 1917, "Human Intestinal Protozoa in the Near East," London.

[16] Boeck, W. C., 1921, "On the Longevity of Human Intestinal Protozoan Cysts," *Amer. Jour. Hyg.*, 1: 527–540.

[17] Root, F. M., 1921, "Experiments on the Carriage of Intestinal Protozoa of Man by Flies," *Amer. Jour. Hyg.*, 1: 131–153.

[18] Sellards, A. W., and Theiler, M., 1924, "Investigations concerning Amœbic Dysentery," *Amer. Jour. Trop. Med.*, 4: 309–330.

These data all favor the conclusion that there are sufficient cysts produced and that these are capable of withstanding temperature and other conditions outside of the host so that enough of them succeed in contaminating the food and drink of man to initiate new infections and thus keep the race from dying out. Moist conditions, an equable temperature and bad sanitation thus offer the most favorable conditions for the spread of intestinal Protozoa. These conditions occur more often among rural than among urban populations and most frequently in the tropics where soil pollution is customary.

The prevention of transmission of intestinal Protozoa is largely a sanitary problem. There is a tendency for these organisms to spread in families which is suggestive. Soiled hands, the common towel, food that is insufficiently cooked after becoming contaminated by food handlers in markets, restaurants and private homes all favor infection. Recently the thorough washing of uncooked food and its submersion for thirty seconds in water at 80° C. has been recommended as preventive measures for visitors to China (Mills, Bartlett and Kessel, 1924).[19] Efforts to control should be directed toward the elimination of soil pollution, the better disposal of human excrement, the screening of latrines from flies and the destruction of these and other insects, such as ants and cockroaches, that may be responsible for the contamination of food by fecal material containing cysts.

One fact of considerable biological interest brought out by these studies is the active rôle played by the host and the passive rôle of the parasite in transmission. We are accustomed to speak of these Protozoa as invading the host, but, as a matter of fact, they depend entirely on the behavior of the host for their transfer from man to man. Human beings not only contaminate their own food and drink, but carry the parasites by peristalsis into the large intestine, which is the normal habitat of all but *Giardia lamblia* and *Isospora hominis*. *Giardia lamblia* overcomes the action of peristalsis by seeking refuge among the villi of the duodenum, where it clings to the cells by means of its sucking disc, and the sporozoites of *Isospora hominis* escape from the current within the lumen of the intestine by penetrating cells in the intestinal wall.

BLOOD-INHABITING PROTOZOA

So far as is known all the blood-inhabiting Protozoa of man are transmitted by insects and each species of protozoon is carried by one or a very few species of insects. This has an important influence on the geographical distribution of this type of proto-

[19] Mills, R. G., Bartlett, and Kessel, J. F., 1924, Weekly calendar, Peking Union Medical College, June 3, 1924.

zoon. Intestinal species have been found wherever man exists, but blood-inhabiting species are restricted in their distribution to the habitats of their insect vectors. That part of this subject concerned more particularly with the entomological aspects of transmission is omitted from the following account and emphasis placed on the parasite itself.

TRYPANOSOMES

Trypanosoma gambiense and *Trypanosoma rhodesiense,* the organisms of African sleeping sickness, are usually transmitted by tsetse flies belonging to the species *Glossina palpalis* and *Glossina morsitans,* respectively. Other species of the genus *Glossina* may perhaps serve as vectors under favorable circumstances. If one of these flies bites an infected host and then within two hours bites a susceptible host, the latter may become infected by direct mechanical transfer, and biting flies of other genera may also bring about infection in this way; but the usual method of transmission involves a cycle of development in the body of the tsetse fly during which the trypanosomes are not infective. At the end of this cycle, which requires for *Trypanosoma gambiense* about three weeks and for *Trypanosoma rhodesiense* about two weeks, infective trypanosomes reach the salivary glands, where they remain until they are injected into a new host by the fly. Many lower animals, as well as man, are susceptible to infection with these species of trypanosomes and wild game, especially antelopes, are supposed to serve as reservoirs from which the tsetse flies may acquire their infection.

The third species of trypanosome of man, *Trypanosoma cruzi,* the organism of Chagas' disease in South America, is transmitted by a large bug, *Triatoma megista,* which lives in the crevices in the mud walls of native huts during the day and comes out to feed, usually on the face of the victim at night. Several other species of the genus *Triatoma* may act as vectors and a species of another genus, *Rhodnius prolixus,* may also be guilty, since it is known to be infected in nature. Just as in the other trypanosomes, *Trypanosoma cruzi* undergoes a cycle of development in the bug ending in infective forms; but these are located in the rectum and are voided by the insect at the time it bites. The person bitten gets some of this material into his mouth and ingests it or else the parasites gain entrance through the wound or through the mucosa of the nose and eyes. After much effort specimens have been found in the salivary glands of the bug, but it seems probable that infection very seldom occurs by inoculation.

LEISHMANIAS

The literature regarding the transmission of the *leishmania* Protozoa that cause kala-azar, oriental sore and espundia is very extensive, but most of it is inconclusive. Bedbugs, fleas and sandflies have been suspected, but at the present time it can only be stated that sandflies of the genus *Phlebotomus* are known to transmit *Leishmania tropica* of oriental sore and probably transmit those of the other two diseases as well.

MALARIAL ORGANISMS

The three species of malarial organisms are transmitted only by female mosquitoes of the genus *Anopheles.* A cycle of development takes place in the stomach cavity and stomach wall; and finally the infective stages, sporozoites, become lodged in the salivary glands and are injected into new hosts when the mosquito bites. The temperature of the air has a considerable influence on the length of the cycle in the mosquito. For example, the benign tertian parasite, *Plasmodium vivax,* completes its cycle in eight or nine days at the optimum temperature of 25 to 30° C; it requires ten to twelve days at 24° C; eighteen to nineteen days at 18 to 22° C and develops abnormally at 16° C and 35° C. The quartan parasite, *P. malariæ,* develops best at 22° C in eighteen to twenty-one days; and the estivoautumnal or malignant tertian parasite at 30° C in ten to eleven days. It is evident that if the temperature is too high (35° C +) or too low (16° C –) the mosquitoes do not become infected. This has an important bearing on transmission, since in countries where a temperature of 16° C or below prevails during the winter the malarial organisms are not carried over from the previous autumn in mosquitoes, but in man, which constitutes their only reservoir. It is therefore from man that mosquitoes receive their infection in the spring and if human reservoirs could be eliminated transmission would be impossible and malaria quickly stamped out.

Mosquitoes do not become infected unless they ingest a large number of the sexual stages in the life cycle of the parasite. A sufficient number of these would not usually be present if it were not for the phenomenon of relapse. The usual course of a malarial infection includes an acute period, during which the parasites multiply until enough are present in the blood to bring about symptoms; then a decrease in the number of parasites until none can be found in the blood by ordinary routine measures. This latent period may last for weeks or months; but often, because of some change in the host-parasite relationship, this period gives way to a period of relapse during which the parasites again increase rapidly in numbers and the patient again exhibits symptoms. A person may remain infected for years, suffering relapses from time to time. In many cases these relapses occur in

the spring just as the mosquitoes become active. It is obvious then that relapses are largely responsible for the transmission of malaria and for this reason the cause of relapse is the most important problem in malaria.

The three principal theories to acoount for relapse are: (1) the undeveloped sexual forms of the parasite (gametocytes) that remain in the blood after symptoms disappear are stimulated to develop parthenogenetically, thus bringing about an increase in the numbers of parasites; (2) resistant forms of the parasite lie dormant somewhere within the body until some change in their habitat awakens them to renewed activity; and (3) asexual reproduction continues, but most of the offspring are destroyed as soon as formed until the physiological state of the host becomes modified in some way that allows a greater number to survive than are destroyed, the result being an increase in numbers ending in another clinical attack. The third theory has considerable evidence in its favor, some of which will now be presented.

The organism of bird malaria, *Plasmodium præcox,* with which Sir Ronald Ross first demonstrated the transmission of malaria by mosquitoes, is a favorable species with which to carry on malaria studies because it can be grown *in vivo* in canaries and is easily transferred from one canary to another. Experimental work has been in progress on this species in the laboratory of medical zoology at the School of Hygiene and Public Health of the Johns Hopkins University since the school was established in 1918 (Hegner, 1926).[20] Our method of infection is to prick a vein in the leg, suck up a few drops of infected blood into a syringe containing saline or sodium citrate solution and inject it into the breast muscle or peritoneal cavity of a fresh bird. On the average, parasites appear in the blood of this bird about five days later; they increase for about five days when the maximum number is reached; and then decrease until in about five days more they again disappear from the blood.

From that time on the bird remains infective to other birds if its blood is used for inoculation, but the parasites are so few in the blood that they are not revealed by ordinary routine examination. Whitmore (1918)[21] had one canary that remained infective for twenty-nine months and Mazza (1924)[22] has recently reported a bird from which he obtained new infections after a period of four years and two months. Apparently the infection continues as long as the bird lives.

That asexual reproduction continues during the latent period after the acute infection subsides is evident from studies made by Ben-Harel (1923),[23] who was able to find stages undergoing asexual multiplication in spleen and bone marrow in five birds that were sacrificed at intervals of from two weeks to six months after the beginning of the latent period.

Further evidence that the strain is maintained during the period of latency by asexual reproduction was furnished by L. G. Taliaferro (1925),[24] who by patient search and statistical methods demonstrated that a periodicity exists in the asexual cycle of bird malaria; the cycle is twenty-four hours long in a strain obtained by Hartman in Baltimore. Not only does this periodicity exist during the acute phase of the infection but also during the latent period and throughout subsequent relapses. Segmentation in this strain took place at the same time every day (about 6 p. m.). Latency appears to be due, therefore, not to a retardation of asexual reproduction but to the destruction of young parasites; and relapse is due on the other hand to some change that prevents this destruction.

What conditions within the host are responsible for the changes that bring on relapses are now under investigation. We view the blood stream of the bird (and of man) as a culture medium and are attempting to modify infections by changing this medium. The fact that malarial organisms will live in artificial cultures only in the presence of sugar led us to attempt to increase and decrease the sugar content of the blood (1) by feeding sugar to increase the amount and (2) by treating birds with insulin to decrease the amount present. Our results so far (Hegner and MacDougall, 1926)[25] have been surprisingly successful. Preliminary experiments indicate that in birds that are given daily doses of insulin the infection is not so severe as in controls, and that when sugar is regularly fed to birds each day during the hours when segmentation is going on the parasites continue to in-

[20] Hegner, R. W., 1926, "Studies on Bird Malaria," *South. Med. Jour.,* May, 1926.

[21] Whitmore, E. W., 1918, "Observations on Bird Malaria and the Pathogenesis of Relapse in Human Malaria," Johns Hopkins Hospital Bull., 29: 62–67.

[22] Mazza, S., 1924, "On the Duration of Relative Immunity in Malaria of Birds," *Jour. Trop. Med. and Hyg.,* 27: 98–99.

[23] Ben-Harel, S., 1923, "Studies of Bird Malaria in Relation to the Mechanism of Relapse," *Amer. Jour. Hyg.,* 3: 652–685.

[24] Taliaferro, L. G., 1925, "Infection and Resistance in Bird Malaria with Special Reference to Periodicity and Rate of Reproduction of the Parasite," *Amer. Jour. Hyg.,* 5: 742–789.

[25] Hegner, R. W., and MacDougall, Mary S., 1926, "Modifying the Course of Infections with Bird Malaria by changing the Sugar Content of the Blood," *Amer. Jour. Hyg.,* 6: July, 1926.

crease beyond the maximum number characteristic of normal infections and the infection eventually ends in the death of the birds. No analyses have yet been made of the sugar content of the blood of these birds and other factors no doubt play a rôle in relapse, but our experiments are very suggestive and we hope when carried further will help solve the problem of relapse, which, because of its bearing on transmission, is responsible for the continued existence of malaria.

R. W. Hegner

London.

SCIENTIFIC EVENTS

THE EXPEDITION OF THE CALIFORNIA ACADEMY TO THE REVILLAGIGEDO ISLANDS

The 1925 Expedition of the California Academy of Sciences to the Revillagigedo Islands, Mexico, is reported to have been most successful in every way. In addition to the collections made covering practically every phase of life on these islands and points on the mainland, there were several items of more than passing interest, notably the establishing of seven new geographic names. These names have been adopted by both the United States and Mexican governments and are as follows:

Angulo Rock.—A small, outlying, flat-topped rock immediately northeast of Asuncion Island, Lower California. It is named for Captain Victor Angulo, Commander of the Mexican National Patrol Vessel, *Presidente.*

Mount Gallegos.—The highest mountain on Clarion Island of the Revillagigedo Group. Chart No. 1688 of the United States Hydrographic Office gives the elevation of this mountain as 1,100 feet. It is named in honor of the late Professor Jose M. Gallegos, explorer for the government of Mexico and a member of the party which, in 1925, explored this mountain.

Mount Evermann.—The central peak of Socorro Island of the Revillagigedo Group. Named for Dr. Barton Warren Evermann, the distinguished director of the California Academy of Sciences and the organizer of this and many other expeditions in which the academy has actively cooperated with the government of Mexico.

Grayson's Cove.—There is a little cove at the west end of Cornwallis Bay, Socorro Island, as shown on Chart No. 1687, of the United States Hydrographic Office. Here, in 1867, Colonel A. S. Grayson's sloop was wrecked. It is the only known supply of fresh water on the island and the suggestion has been made that it be so marked on future charts.

Point Old Man of the Rocks.—This name was given by Colonel Grayson to the point of rocks which formed the eastern boundary of the little cove when he found fresh water.

Ash Heap.—At the south end of San Benedicto Island the highest elevation is attained, 975 feet. This elevation or peak is composed almost entirely of soft volcanic ashes, hence the name.

Herrera Crater.—The central peak of San Benedicto Island is indicated on Chart No. 1687 of the United States Hydrographic Office as being 683 feet high. This peak is named in honor of Professor Alphonso Herrera, the director of the National Museum of Mexico. Professor Herrera took an active part in the expedition.

HAWAIIAN ACADEMY OF SCIENCE

Following the Pan-Pacific Food Conservation Conference, held in Honolulu in August, 1924, a committee was appointed by the American Association for the Advancement of Science, with Dr. L. O. Howard as chairman, to consider some form of cooperation between that organization and the Pan-Pacific Union, under whose auspices the conference was held. In accordance with the recommendations of this committee, a meeting was called of the members of the association residing in Hawaii, to consider the formation of a local organization. A committee was appointed at this meeting to formulate means for a permanent organization.

After some correspondence with the committee of the American Association for the Advancement of Science in Washington, and several meetings of the local members of the American Association for the Advancement of Science, the Hawaiian Academy of Science was organized on July 23, 1925, and a constitution was adopted. The following officers were elected at that time:

President, Dr. Frederick C. Newcombe.
Vice-president, Dr. C. Montague Cooke, Jr.
Secretary-Treasurer, Mr. Edward L. Caum.
Councilors, Mr. Otto H. Swezey, Professor Frederick G. Krauss.

During the year 1925–26 three public meetings of the academy were held, to hear visiting scientists. On November 9, 1925, Dr. C. P. Berkey, geologist of the American Museum of Natural History's Third Asiatic Expedition, spoke on "Evidence of Change of Climate in the Gobi desert." On January 7, 1926, Dr. Edwin G. Conklin, of Princeton University, spoke on "The Mechanism of Evolution." On March 29, 1926, Dr. Carl M. Meyer, of the Hooper Foundation, San Francisco, spoke on "Food Poisoning and Food Infection."

The First Annual Meeting was held May 19 to 22, 1926. Dr. Newcombe gave the presidential address on "A Field for the Hawaiian Academy of Science" and a program of forty scientific papers was presented.

Following the program on May 22, a business meeting was held at which five resolutions were adopted,

and the following officers were elected for the year 1926–27:

President, Dr. A. L. Dean, president of the University of Hawaii.

Vice-president, Mr. F. Muir, entomologist, Experiment Station, H. S. P. A.

Secretary-Treasurer, Mr. E. H. Bryan, Jr., entomologist, Bernice P. Bishop Museum.

Councilor (two years), Mr. C. S. Judd, territorial forester.

These men, together with Mr. O. H. Swezey, and the retiring president, Dr. F. C. Newcombe, will constitute the council.

The Proceedings of the First Annual Meeting, together with abstracts of papers presented, are to be published by the Bernice P. Bishop Museum.

E. H. Bryan, Jr.,
Secretary-Treasurer

Bernice P. Bishop Museum,
Honolulu

CONFERENCE OF SCIENTIFIC MEN AT THE WORKS OF THE GENERAL ELECTRIC COMPANY

A party of 20 college professors, representing 18 universities, are visiting Schenectady for the professors' conference at the General Electric works which will continue until July 31.

The delegation, according to M. M. Boring who is in charge, will make a study of the progress and development of the electrical industry. Each member selected the line of work in which he is most interested and several who signified varied interests will be transferred each week or two to a different department.

The list, with the name of the college they come from and the work they have been assigned, follows: H. W. Anderson, University of Kansas, radio department; S. W. Anderson, Virginia Military Institute, testing department; F. C. Caldwell, Ohio State University, illuminating engineering laboratory; G. H. Carlovitz, Vanderbilt University, testing department; J. A. Correll, University of Texas, industrial engineering department; R. W. Dickey, Washington and Lee University, industrial engineering department; J. L. Ellis, Georgia School of Technology, testing department; F. C. Evans, Cornell University, turbine engineering department; W. B. Hall, Yale University, industrial control department; S. F. Hart, Syracuse University, factory, building 18; H. H. Higbee, University of Michigan, illuminating engineering laboratory; E. W. Johnson, University of Minnesota, central station department; A. R. Knight, University of Illinois, central station department; J. H. Kuhlman, University of Michigan, direct current engineering department; K. M. McDonald, University of Alabama, factory, building 16; G. E. Mercer, Lafayette College, general engineering laboratory; C. B. Parker, Syracuse University, alternating current engineering department; C. A. Pierce, Worcester Polytechnic Institute, factory, building 16; C. S. Rankin, University of Delaware, testing department; W. H. Setchell, University of Porto Rico, turbine engineering, and F. A. Spencer, Norwich University, industrial engineering department; B. B. Brackett, the University of North Dakota.

An informal dinner was given the professors by the company at the Mohawk Golf Club on June 30. Several of the company's officers were present, but no speeches were made. The delegation visited on July 8 the Pittsfield works of the company for a special demonstration in the million volt laboratory.

In addition eight other professors are spending the summer months studying in various departments of the company. They are: Professor John G. Pertsch, Cornell University, central station department; Professor V. Karapetoff, Cornell University, general engineering laboratory; Dr. C. F. Greene, University of Illinois, alternating current engineering department; Professor G. A. Goodenough, University of Illinois, turbine engineering department; Dean C. E. Magnusson, University of Washington, central station department; Professor J. M. Bryant, University of Texas, in office of R. E. Doherty, consulting engineer; Professor D. A. Bureau, University of Kentucky, industrial control department, and Dr. A. A. Bennett, Lehigh University, alternating current engineering department.

TESTIMONIAL DINNER TO CARL BARUS

To mark the retirement from active service of Carl Barus, since 1895 Hazard professor of physics and since 1903 dean of the graduate department of Brown University, a dinner was tendered him by over sixty members of the corporation and faculty on May 21, 1926. Dean Barus has been made emeritus professor and will continue his researches in the laboratory. At the dinner, letters of felicitation were read from Professors Michelson, of the University of Chicago; Hall, of Harvard; Crew, of Northwestern; Hastings, of Yale, and Nichols, of Cornell. Vice-president Mead presided and there were addresses referring to various phases of Dean Barus's work by President Faunce, Professors Bronson and Koopman of the faculty, Professor H. N. Davis, of Harvard, and Mr. John R. Freeman, the well-known engineer. A book containing a congratulatory address and the signatures of members of the corporation and faculty was presented and Dean Barus responded. In closing he said:

In the third place, let me refer to my original work. Naturally, if a student has been hammering away ever since 1879, pretty steadily, he must have accumulated a lot of litter, much of which, perhaps, should long since have been swept away. But the Fates are not to be bribed either by pother or importunity. Out of 1,000 men who are called, one (probably the ratio is much smaller) is chosen to do glorious scientific work. The others? Their lot is to be failure. They may be equally or even more industrious, they may have equal or even greater brain power—the other 999 exist simply to make the illustrious one in whom they culminate, possible. After that, the world will say to each in words of poetic brevity: "The man has done his duty, the man may go." And go they do, pretty quickly, to a gentler lethe, flowing between banks of amaranth and asphodel.

Gentlemen, I am one of the 999 about to be forgotten. But after all, what difference does it make! Time will come, the time is probably close at hand when even the Newtons crowd too numberless for memory. All that we can do is to be true to the little orbit to which we have been assigned. We do not understand it, we shall never see the end; but we believe—and this is a matter of pure faith, mind you—that it is somehow a part of a stupendous whole, that it fits into a preordained and inscrutable scheme of growth; or that we also, like the stars, are enlisted in a kind of cosmic team work, needing neither excuse nor applause, because it is sufficient in itself.

APPOINTMENTS AT THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

THE Board of Scientific Directors of The Rockefeller Institute for Medical Research announces the election of Dr. Charles R. Stockard as a member of the Board of Scientific Directors.

The following appointments and promotions are announced:

Associate Members

Dr. John W. Gowen
Professor Duncan A. MacInnes
Dr. Norman R. Stoll

Associate

Dr. Eggert Möller

Assistants

Mr. Lawrence R. Blinks
Dr. Philip G. Cohen
Dr. Walter P. Covell
Dr. John A. V. Davies
Dr. Lewis A. Eldridge, Jr.
Dr. Jacob Furth
Dr. Donald M. Hetler
Mr. Thomas P. Hughes
Mr. Alfred G. Jacques
Dr. Lawrence S. Kubie
Dr. Eaton M. MacKay
Dr. Julius Sendroy
Mr. Henry Stevens
Dr. Fred W. Stewart
Dr. Alphonso Walti

Fellows

Mr. Philip R. Averell
Mr. Irving A. Cowperthwaite
Mr. Frederick O. Zillessen

Associate to Associate Member

Dr. Rudolf W. Glaser
Dr. Philip D. McMaster

Assistant to Associate

Dr. Charles A. Doan
Dr. Douglas R. Drury
Dr. James A. Hawkins
Dr. Moses Kunitz
Dr. Clara J. Lynch
Dr. Ida W. Pritchett
Dr. Lars A. Welo

Dr. Albert B. Hastings, hitherto an associate in the Department of the Hospital, has accepted an appointment as professor of physiological chemistry at the University of Chicago.

Dr. David I. Hitchcock, hitherto an associate in the Division of General Physiology, has accepted an appointment as associate professor of physiology and biochemistry at Bryn Mawr College.

THE INTERNATIONAL RESEARCH COUNCIL

AN extraordinary session of the General Assembly of the International Research Council was held in the Palais des Academies in Brussels on June 29, 1926, having been called by special action of the executive committee of the council at a meeting in Paris on October 13, 1925, for the consideration, among other matters, of proposed amendments to the statutes of the council.

This session was attended by official representatives of the principal scientific bodies of twenty of the countries affiliated with the council and unanimous action was taken inviting Germany, Hungary, Austria and Bulgaria to join the council.

The International Research Council was organized during the war by representatives of allied and neutral nations and until the action of this recent meeting in Brussels no provision had been made for the membership of the Central Powers in the council. The action inviting these powers to join the council was taken on the initiative of the representatives of the Royal Society of Great Britain, the American National Research Council and representatives of similar important scientific organizations of Sweden, Norway and Holland.

The American delegates to the assembly were Dr. Vernon Kellogg, permanent secretary of the National Research Council; Dr. F. G. Cottrell, director, Fixed Nitrogen Research Laboratory, U. S. Department of Agriculture, and Professor George D. Birkhoff, Harvard University.

VERNON KELLOGG

PERMANENT SECRETARY,
NATIONAL RESEARCH COUNCIL

SCIENTIFIC NOTES AND NEWS

THE eighty-second birthday of Dr. Harvey W. Wiley and the twentieth anniversary of the pure-food law were celebrated at a gathering of scientific men and pure-food experts at the Waldorf-Astoria Hotel, in New York City, on June 30.

DR. DAVID STARR JORDAN has been elected to honorary membership in the Pekin Society of Natural History.

DR. EDWARD P. WARNER, professor of aeronautics at the Massachusetts Institute of Technology, has been nominated by President Coolidge as assistant secretary of the navy.

DR. FRANK BILLINGS received the honorary degree of doctor of science at the commencement exercises of Northwestern University on June 14.

DR. CLYDE FISHER, of the American Museum of Natural History, received the degree of doctor of laws at the commencement of Miami University.

THE degree of doctor of science has been conferred upon Homer Clyde Snook, of the Bell Telephone Laboratories, by his alma mater, Ohio Wesleyan University.

AT the June commencement of the University of Porto Rico the degree of doctor of science was conferred on Alexander Petrunkevitch, professor of zoology, Yale University; Herbert Hice Whetzel, professor of plant pathology, Cornell University, and Frank D. Kern, professor of botany and dean of the graduate school of the Pennsylvania State College.

AT the fifty-fourth annual commencement of Stevens Institute, Harry de Berkeley Parsons, professor emeritus at the Rensselaer Polytechnic Institute, received the degree of doctor of engineering.

IN recognition of the service rendered to France by the Rockefeller Institute for Medical Research, in organizing and maintaining in New York City the War Demonstration Hospital for the training of surgeons in the technique of the Carrel-Dakin treatment, an official delegation from the French government, headed by Monsieur Marcel Knecht, on July 1 awarded the following decorations: The gold cross of the Assistance Publique to Dr. Rufus Cole, the silver cross to Dr. George A. Stewart and Miss Nancy P. Ellicott and the bronze cross to Miss Mary B. Thompson, Miss Katherine M. Christhilf and Miss Eleanor Evans; while the silver cross of health was awarded to Mr. Henry James and the bronze cross to Mr. Edric B. Smith and Mr. Charles B. Spies.

CARL AKELEY, explorer and taxidermist of the American Museum of Natural History, has been nominated for the John Price Wetherill medal of the Franklin Institute, for his invention of a moving-picture camera designed for photographing wild animals.

DR. MAX SCHLOSSER, formerly head curator of the Bavarian state paleontological collections, has been elected a member of the Russian Academy of Sciences.

ON the occasion of the celebration of the fiftieth anniversary of the telephone on June 24 a luncheon was held in London by the British Institution of Electrical Engineers. In the afternoon Sir Oliver Lodge delivered a lecture on "The History and Development of the Telephone," which was preceded by the presentation of the Faraday Medal to Colonel R. E. B. Crompton. The annual conversazione was held in the evening.

PROFESSOR A. BRACHET, professor of anatomy in the University of Brussels, has been elected a member, and Professor Ch. Pérez, professor of zoology in the University of Paris, a foreign associate, of the Royal Academy of Sciences, Letters and Arts (Scientific Class) of Belgium.

THE Ramaer medal, awarded for work that during the last five years has contributed most to the progress of neurology and psychiatry in the Netherlands, is to be conferred on Dr. A. de Kleijn, Utrecht, for his research on the physiology of the otolith apparatus, the static sense, tonic reflexes, etc.

DR. V. N. KRIVOBOK, associate in the bureau of metallurgical research of Carnegie Institute of Technology, has been awarded a grant of $500 by the Iron and Steel Institute of Great Britain to assist him in carrying out a photomicroscopic study of recrystallization of metals after cold-working.

IN 1924 the Simmons fellowship was founded at Mellon Institute of Industrial Research, University of Pittsburgh, to carry on a broad study of problems in the promotion and maintenance of healthful sleep. Dr. H. M. Johnson and Mr. G. E. Weigand, psychologists, and Dr. T. H. Swan, physical chemist, have been conducting this research during the past year. Recently Dr. Carney Landis, physiologist, has tempo-

rarily joined the personnel of the investigation. It is announced that from now on there will be two separate Simmons fellowships at the Mellon Institute. One of them will continue the research on the physiological and psychological factors of sleep under the supervision of Dr. Johnson. The other fellowship, held by Dr. Swan, will be concerned chiefly with the subject of bedding materials. This investigational work is being supported primarily for the benefit of the public and consequently the experimental results will be published.

WE learn from *Nature* that the following have been elected officers of the Manchester Literary and Philosophical Society for the ensuing year: *President,* Dr. H. Levinstein; *Vice-presidents,* Professor W. L. Bragg, Professor H. B. Dixon, Mr. E. A. Eason, Dr. R. S. Willows; *Secretaries,* Mr. John Allan, Professor W. H. Lang; *Treasurer,* Mr. R. H. Clayton; *Librarians,* Mr. C. L. Barnes, Dr. Wilfrid Robinson; *Curator,* Mr. W. W. Haldane Gee.

THE following officers were elected at the anniversary meeting of the Linnean Society held on May 27: *President,* Dr. A. B. Rendle; *Treasurer,* Mr. Horace W. Monckton; *Secretaries,* Dr. W. T. Calman (zoology) and Mr. John Ramsbottom (botany). *New Members of Council:* Mr. Reginald Cory, Professor J. Stanley Gardiner, Professor E. S. Goodrich, Dr. E. Stuart Russell and Dr. E. J. Salisbury.

CAPTAIN ROALD AMUNDSEN passed through New York City on his way to Norway on July 3. He plans now to retire to private life.

M. PAUL SABATIER, known especially for his contributions to the chemistry of catalysis, will visit the United States in September.

DR. A. H. WESTERGAARD, of the Geologic Survey of Stockholm, has come to America as the guest of the Princeton Summer School of Geology and Natural Resources.

PROFESSOR ALEX. M. SMITH, of the University of Edinburgh, is spending a six weeks' period of research in the department of soils of the University of Wisconsin.

L. F. HITCHCOCK, biologist of the Commonwealth Prickly-Pear Board of Australia, visited the U. S. Department of Agriculture in May. Mr. Hitchcock is to take up the work in the United States and Mexico in relation to the insect enemies of the prickly pear.

SAMUEL T. DANA, director of the Northeastern Forest Experiment Station, represented the forest service at the World's Forestry Congress in Rome. William N. Sparhawk, of the Washington office of the forest service, was delegated to the congress by the Society of American Foresters. Other members of the forest service in attendance were John D. Guthrie, assistant district forester in charge of public relations of the North Pacific District, and George M. Hunt, chief of the section of wood preservation in the Forest Products Laboratory.

BETWEEN thirty and forty American professors and students have announced their intention to attend special lectures and demonstrations by professors of the University of Leyden during American Week from July 5. Professor William Einthoven, the physiologist, and Professor Henry A. Lorentz, the physicist, will deliver lectures, while the liquefaction of helium, for which the university became famous through the experiments of the late Professor Kamerlingh Onnes, will be demonstrated by his successor, Professor W. H. Keesom.

IN behalf of the widow and friends of Professor Harold C. Ernst, first professor of bacteriology at the Harvard Medical School, a memorial room, to be used as a library, was presented to the school at the conclusion of the annual meeting of the Harvard Medical School Alumni Association. The presentation was made by Dr. Elliott P. Joslin, retiring president of the association, and the room was accepted by Dean David L. Edsall. In the room are an oil painting of Professor Ernst, given by Mrs. Ernst, and also a portrait of Dr. Ezekiel Hersey, an ancestor of Dr. Ernst and the founder of the Hersey chair, the first of the foundations in the school. The portrait of Dr. Hersey was bequeathed to the school by Professor Ernst. In the hall of the main building at the Medical School is a bas-relief of Dr. Ernst, designed and given to the school by Cyrus E. Dallin, who was present when the gift was unveiled by Dr. S. B. Wolbach, professor of pathology at the school.

THE second Victor Horsley Memorial Lecture will be delivered at the House of the British Medical Association on July 9, by Mr. Wilfred Trotter, surgeon to University College Hospital. The subject of the lecture is "The insulation of the nervous system." The chair will be taken by Sir John Bland-Sutton, president of the Royal College of Surgeons of England.

As has already been reported in SCIENCE, Dr. Carnie Blake Carter, an industrial fellow of Mellon Institute of Industrial Research, University of Pittsburgh, met with death in a train wreck near Blairsville, Pa., on June 16. A correspondent writes: Dr. Carter, who received his professional education at the University of North Carolina (B.S., 1913; M.S., 1914, and Ph.D., 1916), had spent ten years in research in organic chemistry at the institute. Since 1919 he was engaged in an investigation of the production of chemicals used in the manufacture of synthetic resins and made a number of important discoveries that have

been patented. He was classed among the most brilliant of the younger organic chemists of the country.

The sixth annual meeting of the Western Psychological Association met at Mills College, Oakland, California, June 18 and 19. The retiring president, Professor W. R. Miles, of Stanford University, exhibited a series of motion-picture films showing the learning and other performance of rats. Professor Harvey A. Carr, of the University of Chicago, president of the American Psychological Association, attended the meeting and gave an address on "Animal Learning." The officers elected for the succeeding year are: *President,* Dr. Kate Gordon, University of California, Southern Branch; *Vice-president,* Dr. T. L. Kelley, Stanford University; *Secretary-Treasurer,* Dr. Warner Brown, University of California.

At a meeting of the University of Buffalo Physical Science Club, held on June 3, the following officers were elected for next year: Dr. Brian O'Brien, *president;* Professor L. G. Hector, *vice-president.* Since February 1 the club has heard the following speakers: Dr. C. M. Olmstead, on "The Solar Corona"; Professor T. F. Cooke, on "The Permanent Electrification of Solid Dielectrics"; Professor W. F. G. Swann, of Yale University, on "The Relation of Electrodynamics to Terrestrial Electricity, Terrestrial Magnetism and Gravitation"; Dr. L. I. Dana and Dr. O'Brien, on "Reports on the Meeting of the Physical Society at Washington"; Professor E. J. Moore, on "The Value of 'G' at Buffalo, N. Y."

The annual meeting of the Society of Chemical Industry, which begins in London on July 19 and continues throughout the week, will take this year the extended form of a congress of chemists, at which not only British but international chemical interests will be strongly represented. The Duke of York and the Lord Mayor will be present at the delivery by Lord Balfour of the third Messel Memorial Lecture on the opening day at the Mansion House. The program for the week includes an exhibition of British chemical plant at the Central Hall, Westminster. This year Mr. W. J. U. Woolcock, the president, completes two years' service. His successor will be Mr. F. H. Carr.

The Royal Observatory of Belgium, which was founded by the Dutch government in 1826, celebrated its centenary on June 8.

Two members of the Soviet Botanical Expedition recently arrived in an exhausted condition at a small station in Bokhara, 500 miles from Tashkent. They report that natives attacked the expedition and plundered and destroyed the entire equipment. The fate of the other members is unknown.

The Rockefeller Foundation has contributed to the University of Hawaii $20,000 a year for five years as a special research fund for a study of the biological, mental and social characteristics of the peoples of Hawaii.

Under the Clarke-McNary Act, the forest service will distribute $607,670 among 33 states to aid in preventing forest fires and $35,000 will be spent generally in forest taxation studies. Both sums became available on July 1, at the beginning of the fiscal year.

The League of Nations commission of experts on reform of the calendar has decided to recommend that the second Sunday in April be the fixed date for Easter. The decision is subject to agreement with the Holy See, which was not represented at the latest meeting of the commission.

UNIVERSITY AND EDUCATIONAL NOTES

Eugene M. Niles, of Cambridge, who died May 19, leaves, according to the terms of his will, $135,000 to Tufts College, Boston, with the provision that it be used in providing scholarships and rendering assistance to deserving and needy students.

The late Mr. W. W. Rouse Ball, fellow of Trinity College, made the following benefactions to the University of Cambridge: £25,000 to found a professorship or readership of, or directly connected with, mathematics; and a further sum of a like amount to found a professorship or readership of some branch or branches of modern English law; and a further sum of £10,000 to be invested as a separate fund and the income to be used for the benefit of the university library.

Brown University announces the appointment of Dr. Norris W. Rakestraw as assistant professor of chemistry. He will have complete charge of the teaching of inorganic chemistry and will give the courses that were given previously by Professor H. F. Davison. Professor Rakestraw has spent the past year at Oberlin College where he took the place fo Professor Harry Holmes. Dr. Egbert K. Bacon has been appointed instructor in chemistry.

Dr. Philip Ernest Smith, now associate professor of anatomy at the University of California, where he has been for fourteen years, has accepted an appointment to a similar position at Stanford beginning next September.

Dr. Vernon A. Jones, recently appointed associate professor of educational psychology at Clark, will carry on the work which has been conducted for the past thirty-six years by Dr. William H. Burnham, whose retirement was recently announced. Dr. J. W. Bridges, professor of psychology at McGill University, has been appointed special lecturer in genetic psychology during October and November in absence of Professor Walter S. Hunter, who will be in Europe

establishing connections for the *Journal of Psychological Abstracts,* of which he has been made editor.

At the University of Minnesota, the following promotions have been announced in the School of Chemistry: Dr. George H. Montillon, from assistant professor to associate professor of chemical engineering; Dr. Lloyd H. Reyerson, from assistant professor to associate professor of inorganic chemistry; Dr. Henry M. Stephens, from instructor to assistant professor of inorganic chemistry, and Dr. Arthur E. Stoppel, from instructor to assistant professor of technological chemistry. The following promotions have been made in the College of Engineering and Architecture: J. O. Jones from associate professor to professor of hydraulics; George L. Tuve from instructor to assistant professor of steam engineering, and Orrin W. Potter from instructor to assistant professor of drawing and descriptive geometry.

DISCUSSION

AMOEBOID MOVEMENT

In an important recent paper on the subject of amoeboid movement[1] Professor S. O. Mast refers to a hypothesis suggested by me in a former paper.[2] In a footnote on page 407 he says:

> Pantin concludes that locomotion in Amoeba is due to differential imbibition and contraction. He says (p. 61): ''Water is actually abstracted from the hind end of the amoeba, and imbibed by the protoplasm at the anterior end. A water current is therefore set up towards the anterior end. This current, aided by the contraction of the ectoplasmic tube, would give rise to the endoplasmic stream.'' He does not, however, explain contraction, and it seems to me that entrance of water at the anterior end and exit at the posterior end would tend to produce a current in the plasmasol from the anterior toward the posterior end, not in the opposite direction as maintained by Pantin.

I do not want to discuss here fully the complex mechanics of amoeboid movement, but as the above criticism is based upon a misunderstanding I would like to make the matter clear.

(1) The question of the contraction of the gelated "ectoplasm" (= plasmagel) surrounding the fluid "endoplasm" of the amoeba (except at the anterior end) is fully discussed in my paper and on my hypothesis a simple explanation of the contraction is offered, based on the analogy between this and the syneresis of gels (particularly on pages 61, 63 and 64 of my paper).

(2) It would seem that Professor Mast assumes that I intended to convey the idea that, during locomotion, water is imbibed by the anterior end of the amoeba *from the external medium.* As he points out (and as is also pointed out earlier in my paper on page 37), this would result in a protoplasmic stream from the anterior to the posterior end of the amoeba; the reverse of that actually observed.

But on page 37 in my paper reasons are given for supposing that such an imbibition from the external medium does *not* occur. It is there suggested that water gained by the swelling protoplasm of the anterior end comes not from the external medium *but from the posterior protoplasm of the amoeba itself.* Obviously, this will cause a stream from the posterior to the anterior end of the amoeba, as is actually observed to be the case. My hypothesis is thus consistent with these facts.

C. F. A. Pantin

Marine Biological Laboratory,
Plymouth, England

[1] *Journ. Morph. and Physiol.,* 41, p. 347.

[2] *Journ. Marine Biol. Assoc. U. K.,* XIII, p. 24.

DO CILIATED ORGANISMS ROTATE COUNTER-CLOCKWISE WHILE SWIMMING?

In Science of April 9, p. 385, E. E. Wildman asks, in the title of his paper, Why do ciliated animals rotate counter-clockwise while swimming? The best complete answer to this question is: "They don't."

In this paper Wildman says, "A study of ciliated and flagellate protozoa, the larvae of sponges, coelenterata, echinoderms, lamellibranch molluscs and annelids resulted in the rather surprising discovery that they all show a counter-clockwise rotation on the polar axis while swimming."

This far-reaching conclusion is based on the observation of twenty-six species of organisms, including two ciliates, "a *Paramecium* and a *Vorticella* species."

It was fortunate for this generalization that only twenty-six organisms were observed—the twenty-seventh might have turned to the right! For among the ciliate protozoa sixty-two species out of 165 turn to the right (Bullington, '25, Archiv für Protistenkunde); and in the rotifers, another ciliated group, very nearly all of about one hundred species studied (Professor Frazier Cochrane) turn to the right. A large proportion of the flagellates also turn to the right.

From his twenty-six observations recorded above, Mr. Wildman comes to the conclusion that "for the biologist" the meaning of "the freedom of the will" must be limited. The connection is a bit obscure; the paper becomes clear and logical, however, if one substitutes therefor the *obvious* conclusion that "the freedom of drawing conclusions" be limited.

A. A. Schaeffer

University of Kansas

AN INTERCHANGEABLE TYPEWRITER

ON page 477 of the May 7, 1926, issue of SCIENCE a correspondent has visions of a typewriter that will be able to reproduce mathematical symbols, exponents, etc., necessitating two shift keys, and suggests that some typewriter company build such a machine.

Perhaps he and other readers have not seen the mathematical Hammond typewriter, holding 120 characters, numbers and letters (capitals and lower case, as on other typewriters), including useful Greek characters. In addition, a variable spacing device may be found very useful for condensed typing.

This make is an interchangeable type machine and changes may be made instantly to others, as foreign language, chemical, medical, by substituting another shuttle. It has been on the market for a very long time (though the mathematical device is comparatively recent) and I believe the Hammond antedates all the present standard makes by many years, an old model having been used personally by Woodrow Wilson as a student and during his presidential term.

FRANK C. PANUSKA

TEACHERS COLLEGE,
COLUMBIA UNIVERSITY

A DENOMINATIONAL COLLEGE AND EVOLUTION

A DENOMINATIONAL college supported by one of our Protestant churches in Texas was in search of a man to fill the chair of biology, and the following correspondence passed between the president and a man holding a Ph.D. degree from the University of Chicago:

My dear Dr. ———:

I have your very kind favor of March 13th. I am glad to hear from you. I have given your application very careful consideration.

I wish information from you on the following: (1) What do you believe and teach in regard to the origin of man? (2) Do you sincerely believe the Old and New Testaments to be the word of God, the only infallible rule of faith and practice? (3) Would you obligate yourself while a member of this faculty not to teach anything that is opposed to any doctrine of the standards of the Presbyterian Church?

The Board of Trustees will require definite answers on these questions before electing any man to the Chair of Biology; therefore it is necessary for us to get very definite information along this line before we can proceed at all.

Hoping to hear from you at your earliest possible convenience, I remain

Yours most cordially,

———, President.

Dear President ———:

My answers to your questions are as follows: No. 1. Being a Christian I can not be true to my belief and not teach the truth as I see it. Being a scientist, with all the evidence at hand, I can not but believe in evolution. Man being an animal is governed by the same physiological laws and environmental stimuli as the lower animals. I can not see how any student of the biological sciences, after making a study of life as exemplified in man and the lower animals with their perfect, delicate structures and wonderful adaptations to their environment, can do otherwise than see in and through it all the directing hand of God.

No. 2. I sincerely believe the Old and New Testaments to be the word of God, the only infallible rule of faith and practice.

No. 3. I would obligate myself while a member of your faculty not to teach anything that is opposed to any doctrine of the standards of the Presbyterian Church.

Sincerely,

———,

Professor of Biology

My dear Dr. ———:

Your favor of March 27th to hand.

I am not sure as to what you really mean in your answer concerning the origin of man; neither do I understand fully and clearly your position on the subject of evolution. I do not know whether you really believe in evolution in the most thorough meaning of the word, or whether you believe more in development.

I do not care to do more than simply get correctly your view of the origin of man and your position on evolution as a theory. If you do not object, I should be glad to have an additional statement from you in regard to this matter. I am willing to say that I have been considering most favorably your application, and want to deal with it with everything clearly before me.

Hoping to hear from you, I remain, with best wishes,

Yours most cordially,

———, President.

Dear President ———:

In answer to your last letter I wish first to say that I am a theistic evolutionist. I believe in evolution as a development, but not as a development produced by chance but by the directing hand of God. I believe that the animals of to-day have been developed by evolution from preexisting, but now extinct, animals and that man is no exception. Therefore, I do not believe that man has evolved from any of the anthropoid apes one sees in our zoological gardens. He has evolved along a line of ancestors predestined to culminate in man as we see him to-day. I do not believe in the theory of "Special Creation."

Sincerely,

———,

Professor of Biology

My dear Dr. ———:

Your very kind favor of April 3 to hand.

I am sorry that your position on the question of evolution is such as to make it impossible for me to recommend you for election to the Chair of Biology. Personally I hold you in high regard.

With very best wishes, I remain,

Yours most cordially,

————, President.

SCIENTIFIC BOOKS

The Biology of Population Growth. By RAYMOND PEARL. Alfred A. Knopf, New York, 1925. pp. 260.

THAT the growth of populations, whether they be of yeast cells, flies, rats or men, has a biological basis is a fact of elementary knowledge, but the essence of Professor Pearl's thesis in his latest contribution is that the *principal* factor in the numerical growth of peoples within modern times is the fundamental biological process of "multiplication of cells by successive division of existing cells."

Present-day discussions of population questions, although usually admitting the soundness of Malthus' arithmetic, have been concerned mainly with various conditions of a more or less temporary character, with the results of man's inventions and "victories over nature," and with the possible influence of "social self-control." Professor Pearl, after long study of the matter from the viewpoint of the biologist, is convinced that these, "the complexities of human behavior, social organization, economic structure and political activity, seem to alter much less than would be expected the results of the operation of those biological forces which basically determine the course of the growth of populations of men, as well as those of yeast cells and . . . flies" (p. 18). In developing his thesis he indulges in no quaint notion of society such as Lester F. Ward propounded a generation ago; society does not have to be regarded as an organism to obey biological laws. "It is the normal natural increase," he says quite simply, "the steady excess of births over deaths—which fundamentally determines the form of the population curve" (p. 18). The proposition that even in such an era as this we can not get away from the most elementary biological fact in accounting for the course of human population challenges keenest interest.

His development of this theme is reading of a fascinating kind. One is loath to attempt to summarize it or to consider it critically in a brief review. For his argument, with a wealth of detail and a refreshing originality of presentation, hangs together so well that it would be unfair to consider it except in its entirety. Only a brief outline is essayed here, with a word or two of comment ventured now and then upon some particular point, as a pardonable reaction to a most stimulating book.

There is general familiarity among students of biology in its broader aspects and of the population question with the previous work of Professor Pearl and his collaborator, Professor Reed, on the mathematical expression of the course of population growth by the curve of the general type—

$$y = d + \frac{k}{1 + e^{a_1x + a_2x^2 + a_3x^3 \dots a_nx^n}}$$

which is commonly referred to as the logistic or "growth" curve. In the present treatise these earlier studies are reviewed and somewhat amplified, particularly on *drosophila* and human populations. Probably the most interesting addendum is that in which he makes use of the vital statistics of the indigenous native population of Algeria. In this instance he believes he has found a human population "which has in the 75 years of recorded census history practically completed a cycle of growth along the logistic curve" (p. 208). The data relating to the Algerian instance are considered *in extenso* and can not be summarized here, but its chief significance, as Professor Pearl points out, lies in the facts that during this period the trend of the birth-rate was unaffected by contraceptive methods, and that the death-rate was unaffected by public health measures. The recorded census histories of other peoples, although some of them cover a longer period of time, yielded only fragments of the curve of growth; here, apparently, was one so nearly complete that it could be used as a fairly good demonstration of the human fitness, as it were, of the mathematical expression. There will be no lack of sympathy with the author in the difficulties of his search for census materials of the kind that he needs for his purpose, since dependable enumerations obtained at regular intervals over a long enough period are hard to find. He has undoubtedly done the best that can be done with the Algerian records, and I confess an envy of his ingenuity in dealing with rather unsatisfactory material, for it is not as satisfactory as could be desired. The impression left is not wholly convincing, so far as the indigenous natives of Algeria are concerned, not only because of the material but also because one wonders how, even if birth and death rates were left untampered with, so complete a cycle of population growth could have been accomplished in so short a time as seventy-five years in any human population. At least, this point does not seem to have been made perfectly clear to the non-biological reader. This, in the light of the manifestly important considerations

which he treats of in the second part of his book, *viz.*, the biological causes influencing the *shape* of the logistic curve.

For, obviously, this is the crux of the question. To engage in the pastime of fitting curves to data of this kind or even to find that they fit, yields nothing more conclusive than argument by analogy in favor of the existence of a hypothesized law, a truism not always fully realized by those who apparently are fonder of their mathematics than their facts. But, characteristically, Professor Pearl has not stopped here, and in following his research beyond this point one can appreciate something of the admiration felt by his students and his associates for his courage in tackling elusive and difficult problems.

That part of the curve of population growth in which we naturally are most interested is the latter half of it, where the curve is "damped off," as it were. The first part of the curve, whether as a whole it describes a complete history of a population's growth or only a single cycle, is easier to understand: it is a form of progression that can be visualized when we think of an excess of births over deaths, of an increasing number of parents, an increasing progeny, and so on. The question of intriguing interest is, what are the factors that arrest the accelerating upward course of the growth and finally bend it until it reaches the asymtote? In fact, we may even leave the actual attainment of this level out of consideration for the present, since we do not know that it actually has been reached or will soon be reached in the history of human populations and concern ourselves with the more immediate reasons why the curve bends at all. To the biological phases of this question the author has addressed the latter part of his inquiry.

The first biological fact he considers in this connection is the inverse correlation of fertility, or the rate of reproduction, with density of population. His prior experiments with *drosophila* are reviewed in some detail and attention is called to the similarity of the equation expressing this association of density with fertility to that expressing Farr's law relating human death-rate to density—a similarity which is logically reasonable because "death and reproduction are both fundamental and antithetical biological phenomena." But in the case of *drosophila* something more than mere overcrowding and the attendant struggle of the fittest is shown to bring about a lowered rate of reproduction, for the astute observation is made that fertility lessened before there was any actual overcrowding, food, temperature and other conditions supposedly having been held constant. Professor Pearl's observations a decade ago upon the fertility of hens confined in quarters having different amounts of floor space pointed to the same phenomenon. "Apparently there is an effect," he concludes, "upon the physiological processes of reproduction resulting from the keeping of large numbers of individuals together in a confined area or space, even though the amount of space or area *per individual* is identically the same in the larger crowds of individuals as in the smaller crowds" (p. 145). In carrying this inquiry into the realm of human populations, he is fully aware of the imperfections of the statistical material relating to density as well as the factors which modify the meaning of the term density when applied to population. Space here does not permit a discussion of the data employed or of his scrutiny of the limitations, and the result only may be stated. By the statistical method of partial correlation he finds that the net coefficient using cities having a population of twenty-five thousand or over in the United States, between the births per one thousand women of the ages fifteen to forty-four and persons per acre holding constant size of populations, per capita wealth, percentage of population age eighteen to twenty attending school, and persons per dwelling, to be $-.175 \pm .057$, a result which he takes to indicate a relation "of the same character fundamentally as that we have found in experimental populations of flies and hens" (p. 155). To those who are accustomed to placing dependence upon coefficients of a higher order of magnitude and bearing a higher ratio to the probable error, when using statistical material of this kind, this result may not be wholly convincing. The extreme variableness of the birth rate from year to year in the small city suggests itself as one weakness in the data, as he has used the birth-rates for only a single year. Professor Pearl, referring to the more positive results for flies and hens, interprets the smallness of the relationship thus indicated as "merely an expression of the fact that human life is in many ways far more complex than that of lower animals" (p. 155). Yet it must be confessed that the doubt intrudes itself, in view of the complexity of human life, that a coefficient of this order can be interpreted with any great satisfaction one way or the other, or, if more factors were held constant, the indication itself might not be changed. This is a question of opinion, however, since it involves not the statistical method but the material in the analysis of which the method is applied.

The second biological consideration he brings forward is the negative correlation of the birth rate with wealth, an observation frequently made by his predecessors, but which he supports by interesting statistical evidence from American data in the form of a net correlation coefficient of $-.615 \pm 0.086$ between the birth-rates for native-born white women in 1920 with the estimated per capita value of all property in

1922 in the different states. Although he admits that he is "certainly no violent environmentalist," he vigorously combats the deduction from this correlation that "somehow high fertility in a group is *in itself* an indication of probable racial unfitness." On the contrary he submits the interpretation that a lessened birth-rate tends to accompany increase in wealth, although he places emphasis upon the consideration that other factors than economic ones are involved.

From this point, the reader is logically led into a discussion of human behavior and the birth rate, which is original not only because the data relating to normal sex behavior are new but also because of the author's implications. His presentation of the data is in the nature of a report upon a study still in progress and he warns against too sweeping conclusions. After an extremely painstaking statistical analysis the material so far collected is interpreted as pointing to a lessened frequency of sexual activity as "the intellectual content of life" becomes "more varied and interesting," an indication which receives support from further statistical evidence pointing to a smaller mean total progeny of men engaged in professional pursuits as compared with that of men engaged in pursuits less intellectual in character. To put it very crudely, the curve is "damped off" not only as a population lives in crowds, and tends to get above the poverty line, but also as it gets away from physical labor and occupations concerned with material matters and becomes more and more engaged in intellectual interests.

These are very stimulating conclusions not merely because they suggest, as the author says, further research at many points, but because of their "humanistic implications." Professor Pearl yields for a few pages only to the temptation to discuss them, but what he says is distinctly worth reading. As it may be inferred, his research has not made him gloomy in his outlook. Population will continue to increase, and the growth in population will very probably lead to wars, but it will not "inevitably increase the general wretchedness of human life apart from wars." In support of this optimistic view, he points to the facts that although we have gone a considerable way in the present cycle of growth, squalor, wretchedness and general unhappiness have not increased; that there is going on an orderly evolution of knowledge of how to control and use natural processes and, finally, that the human race is adaptively responsive to population pressure. To the modern adherent of the "inevitable misery doctrine" who is genuinely interested in an open-minded approach to the population problem Professor Pearl's contribution is to be recommended. No commendation is necessary to those who are conversant with the quality of his scientific work or with the vigor of his writing.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN AUTOMATIC THERMOREGULATOR, DEPENDING ON THE FLOW OF WARMED LIQUID[1]

The following device has proved useful for maintaining a constant temperature in saline solutions that could not be heated by a direct flame; for instance, in the method described by Sollmann and Rademaekers[2] for studying exposed intestines of living animals in a saline bath formed from the abdominal walls, it is necessary to keep the bath at strictly body temperature, and this is done by adding saline solution, warmed to 55°, at a proper rate. This regulation requires a great deal of attention, and this was the immediate occasion for the construction of an automatic flow-thermoregulator. A toluene thermoregulator (I, in the figure), which is inserted in the bath, controls the admission of air and therefore the discharge of warmed saline from a Mariotte bottle (II).

The thermoregulator (I) consists of a glass tube (T) filled with toluene. The lower end of this is bent into a coil (C) which is immersed in the bath. The upper end of the tube is bent into a U, which is filled with mercury (M), with a setscrew (S), by which the level of the mercury can be regulated, as in an ordinary toluol thermoregulator. The tube above the mercury is somewhat expanded with an opening (O) blown in one side about 1 cm above the level of the mercury. The neck of the tube bears a stopper, perforated by a smaller tube, which ends just above the mercury and which is connected with the tube of the Mariotte bottle (II). The latter is maintained at a fairly uniform temperature in an ordinary water bath.

The level of the mercury is adjusted so that it is below (X) when the temperature in the abdominal pouch falls below 38° C., air then passes through (O) in the direction of the arrows into the Mariotte bottle, and the hot saline flows from the tip (P) into the pouch. As the temperature in the pouch rises, the mercury expands, closes X and shuts off the supply of air and therefore the flow from the Mariotte bottle.

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SPECIAL ARTICLES

NEW TERMS IN THE SPECTRA OF ZINC AND MERCURY

We have recently reported (*Nature*, December 26, 1925) a pp′ group in the arc spectrum of zinc. This multiplet is similar to the one found by Ruark in the arc spectrum of cadmium in that it consists of four

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[2] T. Sollmann and A. Rademaekers, "Investigations on Saline Cathartics," *Trs. int. d. Pharmacodyn. et de Thér.*, XXXI. 39, 1925.

lines instead of the usual six; the term p_2' is lacking. We reported, however, a diffuse pair in the exact place where the two missing lines, $2p_1 - 2p_2'$ and $2p_2 - 2p_2'$ should be, but the diffuse nature of this pair seemed to preclude their classification as part of the pp′ group. Since our letter was written, Dr. R. V. Zumstein, National Research Fellow at the University of Michigan, has photographed this region for us with the Hilger E 1 quartz spectrograph, using a 100 ampere zinc arc. In this spectrogram, the four lines (λλ2104.34, 2096.88, 2087.27, and 2079.10) which we classified as the pp′ group, show fine sharp reversals, confirming our assignment. The diffuse pair mentioned above, whose wave-lengths we have determined as 2086.72 and 2070.11, show broad diffuse reversals. They must thus also arise from deep lying terms in the zinc spectrum. Hund (*Zeit. f. Phys.*, V. 33, p. 345, 1925) has shown that there should be expected in zinc a deep lying singlet S″ and singlet D″ term, as well as the triplet p′ term. A singlet D″ would combine with the triplet p term of the arc spectrum to give a diffuse doublet. We believe the pair under discussion to be of this nature and have classified it as

λ	Int.	ν	Classification
2086.72	1R	47906.7	$2p_2 - 2D''$
2070.11	1R	48291.2	$2p_1 - 2D''$

$2D'' = -5028 cm^{-1}$

No pair similar to this has been located in cadmium. Probably in cadmium 2D″ is not so near $2p_2'$ as in zinc.

The spectrum of mercury should be similar to that of zinc and cadmium.

In Hg I we have 1S – 2P, λ = 1849.57, ν = 54065.7. By comparison with the spectra of zinc and cadmium we should expect both the pp′ multiplet of Hg I and $1s - 2p_2$ of the Hg II spectrum to be near this line. The mercury spectrum is not well known in the region below λ2000. We have, accordingly, photographed this spectrum from λ2100–1500, using the mercury vacuum spark in a vacuum grating spectrograph. The spectrum has been examined both for evidence of a pp′ multiplet and for a pair in the expected position of the first pair of the principal series of Hg II.

We have located a group in the expected position which we have classified as the pp′ group of Hg I. This group is:

λ	Int.	ν	Classification
2002.7	6	49933	$2p_2 - 2p_1'$
1900.1	5	52629	$2p_1 - 2p_0'$
1832.6	5	54576	$2p_1 - 2p_1'$
1774.9	4	56341	$2p_0 - 2p_1'$

$2p_1' = -9802$

λλ1833 and 1775 were found strong in the arc by Lymann, λ2003, strong in the arc by Stark. λ1900 has apparently never been observed in the arc. On our spectrogram, these lines have a uniform appearance and the relative intensities above listed. $2p_1 - 2p_0'$ might be otherwise chosen, but has the proper relative position and seems the best choice. The assignment of the other three lines seems certain. It is worth noticing that the excitation potentials of these four lines are, respectively, 6.18, 6.51, 6.75, and 6.97 volts, and that Frank and Einsporn (*Zeit. f. Phys.*, V. 2, p. 18, 1920) in their work with mercury vapor found weak unexplained critical potentials at 6.04, 6.30 and 7.12 volts. The excitation of λ1833 would not be resolved from that of 1S – 2P, λ1849 = 6.73 volts. The variations here are about the maximum allowed in identification by Frank and Einsporn. The recent data of Jarvis (*Bull. Am. Phy. Soc.*, V. I, p. 14, 1926) are in somewhat better agreement and give for these potentials 6.05, 6.46, and 7.13 volts, respectively. It seems quite possible that these weak, unaccounted for, critical potentials represent the excitation by successive impacts of the p′ states from the p states.

We have also located in our mercury spectrum a pair of lines which satisfy the requirements for the first pair of the principal series of Hg II. This pair is

λ	Int.	ν	Δν	Classification
1987.2	10	50312		$1s - 2p_1$
			9834	
1662.6	5	60146		$1s - 2p_2$

If we classify this pair as the first pair of the sharp series of Hg II, there then exists an exact similarity between the relative positions of these lines and the corresponding lines in the spectra of zinc and cadmium. We see that now the lines 1S – 2P, and $2p_1 - 2p_1'$ of the neutral atom, and $1S - 2p_2$ of the once ionized atom, are close together and in the same relative position in the three elements. The frequencies of these lines are given in the folowing table:

	Cd	Zn	Hg
1S – 2P	43691	46746	54066
$1p - 2p_1'$	44088	47894	54576
$1s - 2p_2$	46618	49355	60146

The pair λλ2847.83 and 2224.82 are known to be the second pair of the sharp series of Hg II. As we have now two members of the series, by the use of the Rydberg tables approximate values of the terms 1s, $2p_1$, and $2p_2$ in the Hg II spectrum may be computed. They are

$$1s = 156300$$
$$2p_1 = 106000$$
$$2p_2 = 96200$$

Since they are computed from only the first two terms of the series, they are probably a little too large.

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THE MICHIGAN ACADEMY OF SCIENCES, ARTS AND LETTERS

THE thirty-first annual meeting of the Michigan Academy of Science, Arts and Letters was held at Ann Arbor, March 31 to April 2, 1926. Professor W. G. Waterman, of Northwestern University, attended the meetings as the representative of the American Association for the Advancement of Science. Charles H. Cooley, of the University of Michigan, gave his presidential address on "The Roots of Social Knowledge." General addresses were given by C. C. Little, of the University of Michigan, on "The Genetics of Cancer"; W. G. Waterman, of Northwestern University, on "Sleeping Bear Point—a Unique Dune Area" and by Francis E. Lloyd, of McGill University, on "Motion Picture Studies in the Life-History and Physiology of Spirogyra and Vampyrella." Over 150 papers were read before the eleven sections of the Academy.

During the meeting 102 persons were elected to membership in the academy, and the following were elected to honorary membership:

Charles Mills Gayley, professor of English, University of California.

Herbert Spencer Jennings, professor of zoology, Johns Hopkins University.

Thomas Maitland Marshall, professor of history, Washington University.

Frederick Charles Newcombe, professor emeritus of botany, University of Michigan.

Officers for the current year were elected as follows:

President—L. A. Chase, Northern State Normal School.
Vice-President—Harrison R. Hunt, Michigan State College.
Secretary-Treasurer—L. R. Dice, University of Michigan.
Librarian—W. W. Bishop, University of Michigan.
Editor—Peter Okkelberg, University of Michigan.

Section Chairmen

Anthropology—Carl E. Guthe, University of Michigan.
Botany—B. M. Davis, University of Michigan.
Economics and Sociology—Z. C. Dickinson, University of Michigan.
Geography—L. R. Schoenmann, State Land-Economic Survey.
Geology and Mineralogy—W. A. Ver Wiebe, University of Michigan.
History and Political Science—Preston W. Slosson, University of Michigan.
Language and Literature—C. E. Whitmore, University of Michigan.
Mathematics—A. L. Nelson, College of the City of Detroit.
Psychology—John Shepard, University of Michigan.
Sanitary and Medical Science—Malcolm H. Soule, University of Michigan.
Zoology—Charles W. Creaser, College of the City of Detroit.

L. R. DICE,
Secretary-Treasurer

THE MID-WESTERN ASSOCIATION OF EXPERIMENTAL PSYCHOLOGISTS

THE first meeting of the Mid-Western Association of Experimental Psychologists was held at Northwestern University, Evanston, Illinois, on Friday and Saturday, May 7 and 8. On Friday evening Professor Jastrow, of the University of Wisconsin, spoke on "The Beginnings of Experimental Laboratories in the United States." Professor Jastrow told of the first laboratory established by G. Stanley Hall at the Johns Hopkins University in 1882. From this beginning he sketched the development of laboratories at Clark University, Harvard, University of Pennsylvania, Columbia and Wisconsin.

On Saturday morning papers were presented by: Professor Max Meyer, of Missouri, "Rank Classes versus Centiles"; Dr. H. W. Johnson, Mellon Institute, "Some Recent Experiments bearing on the Problem of Sleep"; Mr. S. N. Stevens, Northwestern, "Some Studies in Experimental Functionalism"; Mr. James Vaughn, Chicago, "The Hydrogen Ion Concentration of the Saliva."

In the afternoon representatives gave reports of experiments in progress at the following laboratories: Kansas, Wisconsin, Minnesota, Missouri, Wittenberg, Iowa and Ohio State. In the evening after dinner President Walter Dill Scott presided while Professor H. A. Carr, of Chicago, gave a paper on "The Weber-Fechner Law" and Professor A. P. Weiss told of the organization and program of the new Ohio State University laboratory.

More than 150 representatives from fifteen colleges and universities were present. A committee consisting of Professors A. R. Gilliland, Northwestern; E. S. Robinson, Chicago; C. R. Griffith, Illinois; Clark Hull, Wisconsin, and C. A. Ruckmick, Iowa, was appointed to arrange for the program and place of meeting for next year.